Preparation for Lab on Regulating Greenhouse Gas Emissions

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Contents

Introduction

For the laboratory period on Monday April 12, we will do a role-playing exercise explore the effectiveness of three different approaches to regulating pollution, such as greenhouse gas emissions: command-and-control, cap-and-trade, and emissions taxes. This reading should serve to prepare you for the exercise.

Zero-Emissions Baseline

To simplify things for doing this exercise, we will calculate costs and benefits with respect to a zero-emissions baseline, where we specify both the marginal and cumulative (or gross) costs and benefits with respect to a condition where there are no emissions.

In this case, from the perspective of the businesses that you will be playing, the costs will be the cost of buying permits to emit CO_2 or the costs of paying taxes on emissions. The benefits to the businesses will be the profits they earn. The costs to society will be the social cost of carbon (the damage caused by global warming) and the benefit will be the combination of revenues the companies generate (this benefits the companies' owners as profit, but the revenues also provide wages for workers and spending by the company, which stimulates the economy; this total economic activity is what we measure as the companies' contribution to the nation's gross domestic product) as well as money received from the players as taxes or payment for emissions permits, which is then refunded to the people through some mechanism, such as a dividend from the government or a reduction in payroll taxes.

The Exercise

The Players

To keep groups small, I will divide the class in half and each half will perform the same role-playing exercise. For the exercise, I will divide the students into three groups:

1. One group will play The Environmental Protections Agency (EPA) and will decide how much to reduce pollution, how many permits to issue, or how much to charge as a pollution tax.

   The EPA's motivation is to produce the best net benefit for society by balancing the costs of reducing greenhouse gas emissions against the benefits of limiting global warming.

2. A second group will play Alpha Electricity: a large power company with a varied portfolio of generating plants including coal, natural gas, and nuclear.

   Alpha's motives are purely to produce the greatest profit for its shareholders regardless of the cost to society of greenhouse gas emissions.

3. A third group will play Beta Industries: a large heavy-industrial conglomerate with many large factories producing steel, aluminum, and petrochemicals such as plastics, paints, and pharmaceuticals.

   Beta's motives are purely to produce the greatest profit for its shareholders regardless of the cost to society of greenhouse gas emissions.

For the purposes of this exercise, we will assume that the EPA can accurately estimate the damage that would be caused by global warming, and thus, that it can also accurately estimate the social benefit of reducing greenhouse gas emissions. However, the EPA cannot accurately assess the costs individual companies will incur when they reduce their emissions. This means that the EPA's estimates of net benefits (benefits minus costs) is limited by its uncertainty about the cost of reducing emissions.

Only the EPA will know the social cost of greenhouse gas emissions, only Alpha will know Alpha's cost for reducing emissions, and only Beta will know Beta's cost for reducing emissions.

Without regulation, Alpha and Beta would each emit 150 million tons of CO_2 per year. The goal of the exercise is for the EPA to reduce pollution to achieve the socially optimal balance between the benefits of economic activity (jobs, wealth, etc.) and the harms of pollution. The goal of each firm is to maximize their profit regardless of the costs or benefits to society or to its competitor.

To keep things simple, emissions cuts will be figured in blocks of 1 million tons, so a firm can cut emissions by zero, 1 million tons, 2 million tons, ..., up to a maximum of 15 million tons (cutting emissions by 15 million tons means the firm reduces its emissions to zero).

The Game

The game will have six stages:

1. First, the EPA will gather information on the cost of abating pollution. A representative of the EPA can ask four questions about each company's marginal costs and benefits (**I recommend asking questions about the marginal profit for the n^{th} million tons of pollution: "what is your marginal profit for the 6th million tons you emit?"**). A representative of each company will answer the question. The representatives may answer strategically, meaning they may exaggerate the costs. The EPA may take this into account in deciding how to use the answers to estimate the true cost of reducing emissions.
2. Second, the EPA will determine three possible courses of action:
    a) A command and control regulation, which mandates a specific emissions by each firm. Because the Constitution guarantees equality before the law, this regulation must impose the same emissions limit on each firm.[1] Based on what it knows about the costs (to the firms) and benefits (to society) of emissions, the EPA will determine how many million tons of emissions to allow (to keep things simple, the EPA should make the amount an even number: 2 million tons, 4 million tons, 6 million tons, etc.) and then divide those emissions allowances equally between the two firms.
    b) A cap-and-trade. Under this program, the total emissions cuts would be the same and the EPA will issue permits to emit CO_2. Each permit will allow the owner to emit 1 million tons of CO_2. Total CO_2 emissions are 30 million tons minus the emissions cuts the EPA wants to impose. Again, to keep things simple, issue an even number of permits. The EPA will give each company an equal number of permits (if the EPA issues 10 permits, it gives 5 to each company).
    c) An emissions-tax program. Under this program, the EPA determines the tax a firm must pay for every million tons of CO_2 it emits. The firms will then decide on their own how much CO_2 they want to emit.
3. Third, the firms determine how much CO_2 they will emit under the command-and-control program (this is easy, because it's the amount the EPA allows).
4. Fourth, permits will be distributed. The EPA will distribute equal numbers of permits to each firm and allow the firms to trade permits with each other.
5. Fifth, we will impose an carbon tax, at the price set by the EPA in stage 2. The two firms will be free to cut emissions by as much or as little as they want (between 0 and 15 million tons each).
6. Sixth and finally, we will reveal the details from each step, including the private information each firm has about its costs, and calculate the deadweight loss under each of the three types of regulation. This will let us discuss and analyze the strengths and limitations of each regulatory program.

Acknowledgements

This exercise was adapted from The Pollution Game, an interactive exercise developed by Jay R. Corrigan, Associate Professor of Economics, Kenyon College.
See J.R. Corrigan, "The Pollution Game: A Classroom Exercise Demonstrating the Relative Effectiveness of Emissions Taxes and Tradable Permits,'' *The Journal of Economic Education* **42**, 70–78 (2011) doi: 10.1080/00220485.2011.536491

[1] The real world is a bit more complex, because the government would be allowed to regulate different industries differently, but would face real obstacles if it tried to impose different emissions limits on different companies within the same industry. Because this exercise is limited to just two companies, we simplify by forcing the EPA to impose identical emissions limits on all firms.

Optional Preparation Exercises:

To prepare for the lab, please do the following exercises. **You do not need to turn it in**, but if you are unable to attend the lab session on Monday April 12, then you should turn it in on Brightspace to get credit for this lab):

1. Table 1 lists the marginal profit a company earns by emitting CO_2. Fill in the blanks in the table to show the total profits it earns at each amount of CO_2 emissions.
2. What level of CO_2 emissions would produce the maximum total profit? How much profit would this be?
3. If the company is emitting the amount of CO_2 that would maximize its profits, and then the Environmental Protection Agency requires the company to reduce its emissions by 5 million tons, what is the total cost for the company to comply with the regulation?
4. What is the marginal cost to comply with the regulation? (Be careful and consider, if the company cuts 1 million tons, then a second million tons, and so forth, what did it cost the company to make the fifth million-ton cut?)
5. If the EPA imposed a tax of \$30 per ton on CO_2 emissions, complete the table to indicate the new marginal profit and total profit at each level of emission.
6. Under a \$30 per ton tax, what level of CO_2 emissions would produce the maximum total profit? What would its total profit be? How much less is this than the total profit you reported in question 2?
7. Table 2 shows the economic value of the marginal environmental harm caused by each additional million tons of CO_2 emissions. Fill in the blanks to indicate the total environmental harm.
8. The marginal net economic impact is the marginal profit generated by emitting each million tons of CO_2 minus the marginal environmental harm. This number is the net benefit to society from emitting an additional million tons of CO_2. If the number is positive, society benefits. If it is negative, society suffers.

   Fill in the marginal and total economic impacts, using the information on environmental harm from Table 2 and the information on marginal profits from Table 1.

9. What is the optimum amount of CO_2 to emit if we consider the net benefit to society (i.e., the net economic impact).

10. If you were going to set a cap on emissions, how many tons would you set the cap at?

11. If you were going to set a tax on emissions, how many dollars per ton would you set the tax at?

Tables: Emissions, Profits, and Harms

\begin{table}

\caption{**Table 1:** Profits versus emissions: The table lists the marginal profit, in millions of dollars, for each million tons of CO_2 it emits. For instance, if it emits one million tons, it earns a marginal profit of $85 million. The total profit for x million tons is the sum of the marginal profits for each million tons from 1 to x.

Fill in the blanks with the total profit the company earns by for each amount of CO_2 emission.}

	No Emissions Tax		$30/ton Emissions Tax	
CO_2 Emissions (million tons)	Marginal profit (million dollars)	Total profit (million dollars)	Marginal profit (million dollars)	Total profit (million dollars)
1	85	85	85 - 30 = 55	55
2	79	79 + 85 = 164	79 - 30 = 49	49 + 55 = 104
3	73	73 + 164 = 237	73 - 30 = 43	43 + 104 = 147
4	67			
5	61			
6	55			
7	49			
8	43			
9	37			
10	31			
11	25			
12	19			
13	13			
14	7			
15	1			
16	-5			
17	-11			
18	-17			
19	-23			
20	-29			

\end{table}

\begin{table}

\caption{**Table 2:** Economic impacts of CO_2 emissions. The table lists the marginal environmental harm, in millions of dollars, for each million tons of CO_2 released into the environment. For instance, the first million tons of emissions cause $5 million in damage.

The right pair of columns shows the net economic impact of the profits generated from the emissions (see Table 1) minus the environmental harm.

Fill in the blanks with the total environmental harm from CO_2 emission and

compute the net economic impact.}

	Environmental Harm		Profits		Net Economic Impact	
CO_2 Emissions (million tons)	Marginal (million dollars)	Total (million dollars)	Marginal (million dollars)	Total (million dollars)	Marginal (million dollars)	Total (million dollars)
1	5	5	85	85	85 - 5 = 80	85 - 5 = 80
2	10	10 + 5 = 15	79	164	79 - 10 = 69	164 - 15 = 149
3	15	15 + 15 = 30	73	237	73 - 15 = 58	237 - 30 = 207
4	20					
5	25					
6	30					
7	35					
8	40					
9	45					
10	50					
11	55					
12	60					
13	65					
14	70					
15	75					
16	80					
17	85					
18	90					
19	95					
20	100					

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